NON REVENUE WATER
AT KUALA LIPIS

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B. ENG (HONS.) CIVIL ENGINEERING

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

One of the main challenges faced by water utilities is the high NRW level in the water distribution system. In 2015, the NRW rate for Pahang was 52.8% compared with the national average of 35%, the third highest rate among the states in Malaysia. To address this issue, Pahang Water Management Berhad (PAIP) has set up a NRW management unit for its district to monitor NRW rates. For the initial stage, there are only three districts in Pahang State which have special units to control the NRW rate of Kuantan, Kuala Lipis and Pekan. However, this research focuses only on NRW in the district of Kuala Lipis. The NRW unit in Kuala Lipis was established in 2016 after the establishment of DMA. There are nine water treatment plants (WTPs) around Kuala Lipis district equipped with 52 DMAs. The establishment of the DMA commenced in 2014 and completed in 2015. To analyze the effectiveness of NRW management in Kuala Lipis district, the discussion focuses on existing conditions, withdrawals, bills and NRWs for every nine WTPs. Comparison for all WTPs has been made to achieve overall NRW management performance from 2016 to 2018. In addition, NRW components were also identified to know factors that contributed to the rate of NRW. Generally, based on the standard water balance there were three components of NRW that consist of physical losses, commercial losses and unbilled authorised consumption. Based on the analysis made, it shows that the main factor that contributed to water losses is the physical losses as proven by the analysis of water losses for each kilometre pipe of each WTP in this report. It shows that there was 2,027 m^3 of water losses occur per day for each kilometer pipe for the year of 2016, 1,800 m^3 for the year of 2017 and 1397 m^3 for the year of 2018. It is about 5,224 m^3 of water loss every day in each kilometre pipe along these three consecutive years. In order to compare flow before and after NRW unit establishment, the analysis made based on the volume of production, billing and NRW for each WTP for three years (2016 until 2018) after the establishment of NRW unit. The comparison of the flow was made based on the baseline rate before the establishment of NRW management. Referring to trend of NRW for all nine WTP, it shows that the rate of NRW varies from year to year and directly proportional to the production and billing rate. There was a lot of difference between the production and billing that occur due to water losses. From all WTP around Kuala Lipis area, only Jelai WTP shown consistence decrease of NRW. This situation occur due to Jelai WTP is the priority since it functions to supply the clean and safe water to the Kuala Lipis city with the highest population rate when compare than others WTP. The highest rate of water losses may lead to insufficient water supply for surround population. Therefore, the overall monitoring and management started at the Jelai WTP which provide supply to the town. For other WTP, the overall monitoring and management would be carried out according to priority due to lack of manpower.

ABSTRACT

Cabaran utama yang dihadapi oleh utiliti air adalah tahap NRW yang tinggi dalam sistem pengagihan air. Pada tahun 2015, kadar NRW bagi negeri Pahang adalah 52.8% berbanding purata kebangsaan 35%. Kadar NRW bagi negeri Pahang adalah yang ketiga tertinggi di kalangan negeri-negeri di Malaysia. Untuk menangani isu ini, Pengurusan Air Pahang Berhad (PAIP) telah menubuhkan satu unit pengurusan NRW bagi daerahnya untuk memantau kadar NRW. Untuk peringkat awal, hanya terdapat tiga daerah di Negeri Pahang yang mempunyai unit khas untuk mengawal kadar NRW; Kuantan, Kuala Lipis dan Pekan. Walau bagaimanapun, kajian ini hanya memberi tumpuan kepada NRW di daerah Kuala Lipis. Unit NRW di Kuala Lipis ditubuhkan pada 2016 selepas penubuhan DMA. Terdapat sembilan loji rawatan air (LRA) di sekitar daerah Kuala Lipis yang dilengkapi dengan 52 DMAs. Penubuhan DMA bermula pada tahun 2014 dan selesai pada tahun 2015. Untuk menganalisis keberkesanan pengurusan NRW di daerah Kuala Lipis, perbincangan ini memberi tumpuan kepada syarat, pengeluaran, bil dan NRW yang sedia ada untuk setiap sembilan LRA. Perbandingan untuk semua LRA telah dibuat untuk mengetahui keberkesanan pengurusan NRW dari 2016 hingga 2018. Selain itu, komponen NRW juga dikenal pasti untuk mengetahui faktor-faktor yang menyumbang kepada peningkatan kadar NRW. Pada umumnya, berdasarkan keseimbangan air standard terdapat tiga komponen NRW yang terdiri daripada kerugian fizikal, kerugian komersil dan penggunaan yang tidak dibenarkan. Berdasarkan analisis yang dibuat, ia menunjukkan bahawa faktor utama yang menyumbang kepada kerugian air ialah kerugian fizikal seperti yang terbukti dengan analisis kehilangan air untuk setiap kilometer paip bagi setiap LRA dalam laporan ini. Ia menunjukkan bahawa ada 2,027 m^3 kehilangan air berlaku setiap hari untuk setiap paip kilometer untuk tahun 2016, 1,800 m^3 untuk tahun 2017 dan 1397 m^3 untuk tahun 2018. Purata kehilangan air dalam setiap kilometer paip sepanjang tiga tahun ini adalah sebanyak 5,224 m^3. Untuk membandingkan aliran sebelum dan selepas penubuhan unit NRW, analisis dibuat berdasarkan jumlah pengeluaran, bil dan NRW bagi setiap LRA selama tiga tahun (2016 hingga 2018) selepas penubuhan unit NRW. Perbandingan aliran dibuat berdasarkan kadar asas sebelum penubuhan pengurusan NRW. Merujuk kepada trend NRW untuk kesemua sembilan LRA, ia menunjukkan bahawa kadar NRW berubah dari tahun ke tahun dan berkadar terus dengan kadar pengeluaran dan pengebilan. Terdapat banyak perbezaan antara pengeluaran dan pengebilan yang berlaku akibat kehilangan air. Hanya LRA Jelai yang menunjukkan penurunan NRW yang konsisten. Keadaan ini berlaku disebabkan LRA Jelai adalah menjadi keutamaan kerana ia berfungsi untuk membekalkan air bersih dan selamat ke bandar Kuala Lipis dengan kadar penduduk tertinggi berbanding dengan LRA yang lain. Kadar kehilangan air yang tinggi boleh menyebabkan bekalan air yang tidak mencukupi bagi penduduk sekitar. Oleh itu, pemantauan dan pengurusan keseluruhan bermula dari LRA Jelai yang berfungsi menyediakan bekalan ke bandar. Pemantauan dan pengurusan keseluruhan bagi LRA yang lain akan dijalankan mengikut keutamaan kerana kekurangan tenaga kerja.

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LIST OF SYMBOLS

AC	Asbestos Concrete
DMA	District Metering Area
FELCRA	Federal Land Consolidation and Rehabilitation Authority
FELDA	Federal Land Development Authority
GIS	Geographic Information System
GPS	Global Positioning System
IWA	International Water Association
LNF	Legitimate Night Flow
MNF	Minimum Night Flow
NNF	Net Night Flow
NRW	Non-revenue water
PAIP	Pengurusan Air Pahang Berhad PAIP
POE	Point of Entry
POU	Point of Use
PRV	Pressure Reducing Valves
PVC	Plasticised Polyvinyl Chloride
PVC-O	Oriented Unplasticised Polyvinyl Chloride
SCADA	Supervisory Control and Data Acquisition
SOP	Standard operating procedure
SPAN	Suruhanjaya Perkhidmatan Air Negara
UFW	Unaccounted for Water
WHO	World Health Organization
WTP	Water Treatment Plant
ZPT	Zero Pressure Test

LIST OF ABBREVIATIONS

π	Simple Boost Pulse Width Modulation
“	Inch
A	Cross Section Area
d	Diameter of Pipe
F	Darcy Friction Factor
g	Gravity Acceleration
h_L	Head Loss
k	Losses Coefficient
km	Kilometre
L	Length
LNF	Legitimate Night Flow
m3/hour	Cubic Metre Per Hour
m3/year	Cubic Meter Per Year
m3/day/km	Cubic Meter Per Day Per Kilometre
mg/l	Milligram Per Liter
mm	Millimetres
MNF	Minimum Night Flow
n	Number of Pipe Flushing and Scouring
NNF	Net Night Flow
NTU	Nephelometric Turbidity Unit
Q	Flow
t	Thickness of Pipe
V	Velocity

CHAPTER 1

INTRODUCTION

1.1 Introduction

Currently, water already becomes the most important global issues. Most of the urban water utilities in developing countries faced water losses in the water distribution system. The water management sector in many Asian cities faced a challenge of the high rates on Non-Revenue Water (NRW). Maintaining water sustainability can become more difficult if large volumes of treated water are lost from a water supply system.

NRW represents the difference between the volume of water that distributed to the water distribution system and the volume that is billed to consumers (Lai Chee Hui, 2013). Normally, there will be different between the volume of water that distributed to the water distribution system and the volume that is billed to consumers. This is due to two main factors which are water losses and authorised consumption. Water losses consist of physical and commercial components. The authorised consumption is divided into unbilled authorized consumption and billed authorized consumption. However, the billed authorized consumption is not categorized as the component of NRW since the revenue will be collected in term of cost of water that used by consumers.

The main components of NRW are physical losses, commercial losses and unbilled authorized consumption. The physical loss is caused by leakage of pipe on the pipeline, storage facilities, problem with the main distribution and service connection. Pipe leakage may occur due to several factors such as low quality of the pipe, improper connection, high pressure and others. However, the commercial loss is due to meter problem, illegal connection, database error and also technical error. The last component which is unbilled authorized consumption occurred due to the usage of water for

firefighting, tanker and also operation purpose. There is a lot of factors that contributes to NRW, but one of the factors is the components of NRW.

In Malaysia, the national average of NRW rate is around 35% to 36%, while the rate of NRW in Pahang state is 48% (Anon., 2017). The high rate of NRW is detrimental to the financial viability of water utilities as well as the quality of the water itself. It is impossible to control the rate of NRW by a hundred percent, but it does not mean that we can do nothing with this problem. In order to reduce the rate of NRW, the proper methods execute is needed such as the pressure control, proper leakage detection, schedule pipe replacement and the quality work installation.

1.2 Problem Statement

It is found that the total of water flow that distributed from water treatment plant to the water distribution system is not the same as the total of water flow that billed to the consumer. Logically, the flows that come in must be the same with flows that come out. If such a situation is not achieved, there is a problem of water losses occur along that water distribution system before it reaches the customer. This phenomenon is known as NRW. This resulted in the amount of water received by the consumer becomes less or no supply at all.

Currently in Kuala Lipis district, records on water production at treatment plant do not tally with the billed consumer. The Pengurusan Air Pahang Berhad (PAIP) of Kuala Lipis district received complaints from the consumer on the lack of water supply or nor supply at all. This confirmed that the NRW is taken place at Kuala Lipis district. The highest level of the NRW is detrimental to the financial variability of water utilities as well to the quality of the water itself. This issue must be tackled seriously and necessary action to be taken in order to avoid a big amount of losses in the future.

1.3 Objectives

The objectives of this study are:

i. To identify the components that contribute to NRW at Kuala Lipis.
ii. To compare the flow before and after NRW unit establishment.

1.4 Scope of Study

The scope of this study focused on the NRW that occurs in the water distribution system at Kuala Lipis district. Comparison between the total flow that distributed to the water distribution system and the total flow that billed to customer for each water treatment plant (WTP) was held to identify the rate of NRW which are the total flow that already lost along the water distribution system. The analysis would be based on production, billing and NRW of each WTP for three years (2016, 2017 and 2018) after the establishment of NRW Unit.

Based on the different of total flow that distributed to the water distribution system and the total flow that billed to the customer, an analysis of NRW components was held to see the flow of water losses that contribute to incremental of NRW rate. The data and information on the physical and commercial losses and unbilled authorised consumption were used as evidence that contributes to water losses and incremental of NRW rate. In order to reduce the rate of NRW in the water distribution system at Kuala Lipis, some analysis was conducted in order to choose the appropriate method to execute to reduce the rate of NRW.

1.5 Significant of Study

For this study, factor contributing to the water losses were identified. Such identification can provide solution to overcome the lack of water being supply to the consumers. It also can reduce the rate of NRW by controlling the water losses through the replacement of aging pipe infrastructure.

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